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This publication gives information on new developments of interest to agriculture on laboratory and field investigations of the du Pont Company and its subsidiary companies.

In addition to reporting results of the investigations of the Company and its subsidiaries, published reports and direct contributions of investigators of agricultural experiment stations and other institutions are given dealing with the Company's products and other subjects of agricultural interest.

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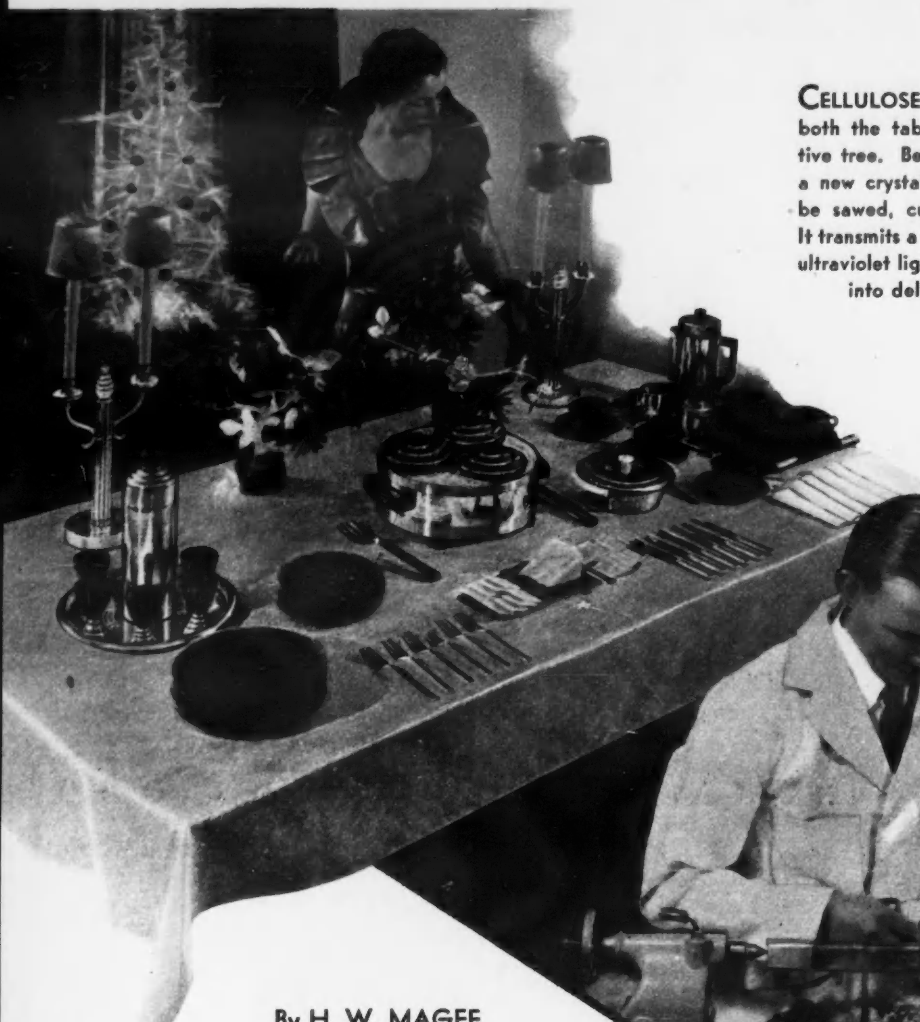
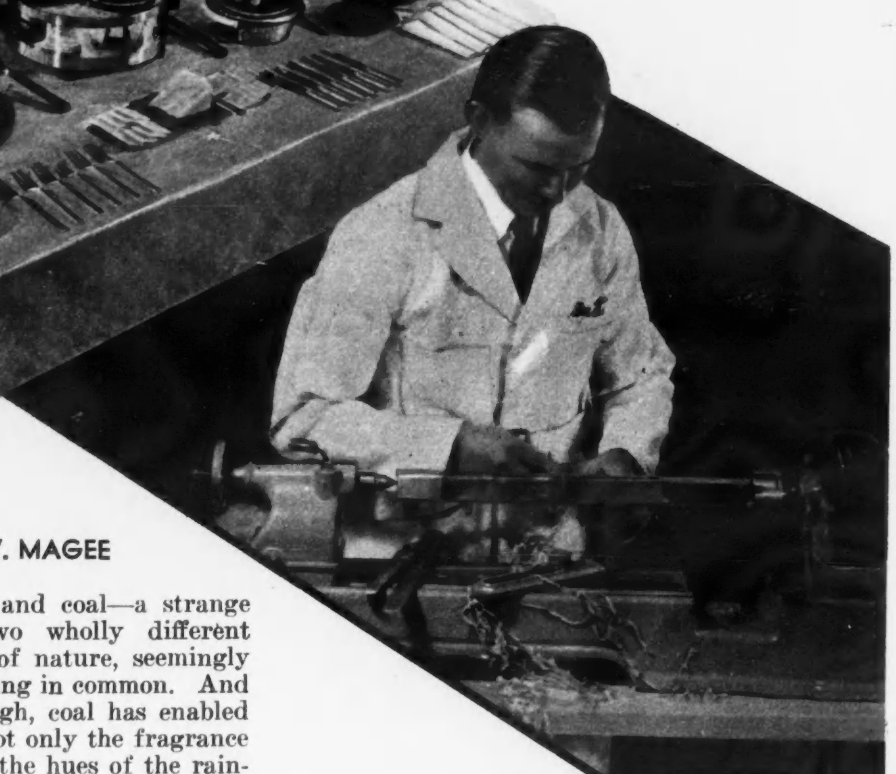
THINGS are NOT what THEY SEEM

PART 2



CELLULOSE was the beginning of both the tablecloth and the decorative tree. Below, machining "Lucite," a new crystal-clear plastic which can be sawed, cut, drilled and polished. It transmits a large portion of the sun's ultraviolet light and can be fabricated into delicate tinted shades.



Photos courtesy E. I. du Pont de Nemours and Company

By H. W. MAGEE

FLOWERS and coal—a strange pair. Two wholly different products of nature, seemingly with nothing in common. And yet, curiously enough, coal has enabled man to duplicate not only the fragrance of the flowers, but the hues of the rainbow as well.

To most of us coal means heat, light, power. But to the chemist it is also the source of coal tar—a sticky, gummy, evil-smelling compound which contains the base for beautiful dyes, rare perfumes and a host of other useful products. The blooming of a lily out of the mire is no more a miracle than the birth of a rich indigo dye or the sweet scent of lilacs from the black, unlovely substance we know as coal tar.

Once, only kings and the very wealthy could surround themselves with brilliant colors and luxurious perfumes. Today, thanks to coal tar and the wizardry of the chemist, the humblest maid can afford to wear a perfumed rainbow around her shoulders. Coal tar has brought inexpensive color and beauty into the lives of everyone. Without coal-tar products, this would be a gray, drab world.

We have seen how chemists of the E. I. du Pont de Nemours and Company pro-

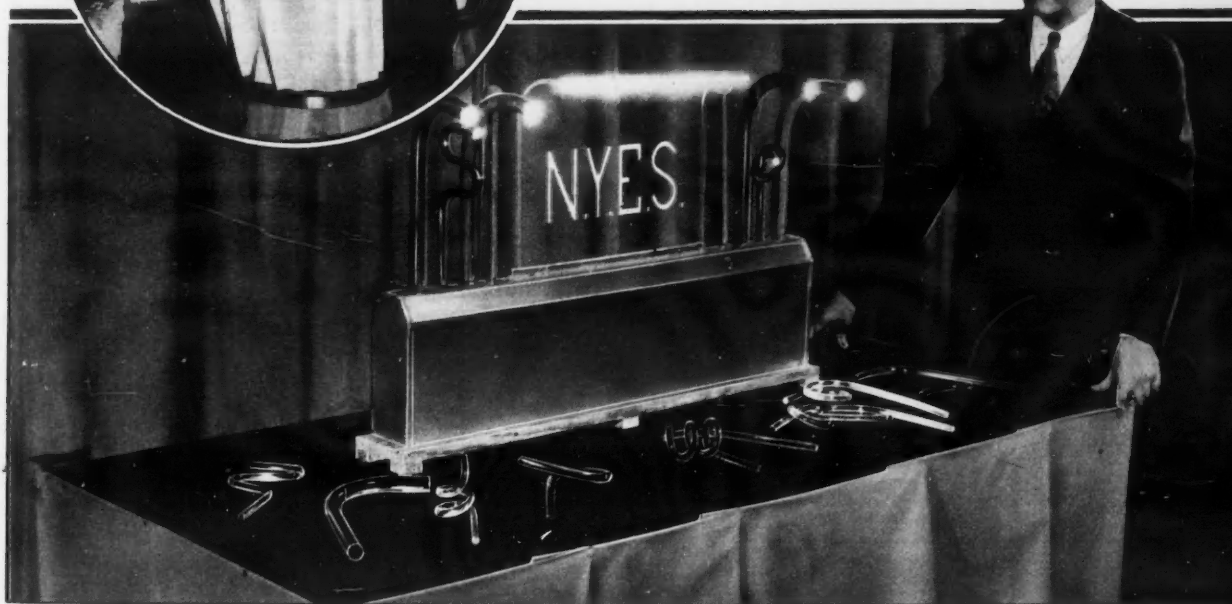
CELLULOSE sponge in foreground has been immersed in water. The one in background is dry. Note increase in size after immersion. Right, this gown has a permanent finish. It can be boiled and does not have to be restarched. The vat dyes used to color it are impervious to washing, sunlight and perspiration. Bottom, model sun room furnished and decorated with products of American chemical laboratories.

BALLOON made of fabric treated with man-made rubber compound. Below, hat made of braided strips of jet-black "Cellophane." Any woman with deft fingers can fashion one like it. Bottom, ornamental enamelware decorated with gay ceramic colors made possible through the development of new chemical products.

duce an array of man-made materials from cellulose as unlike as the finish on your car, the barrel of your fountain pen, the wrapper around your cigar and the lining of your coat. All are born of the stately spruce and the white cotton boll. Now let's observe what marvels are produced when coal and chemistry, instead of cellulose and chemistry, join forces.

When coal is heated, as in making coke, a by-product is the thick, sticky substance known as coal tar. If this gummy tar is distilled, it yields various carbon compounds at different boiling points. These are the "crudes," the intermediate compounds between black, sticky tar and the colorful substances used for dyeing. They go by such imposing names as toluene which, when treated with nitric acid becomes "TNT"; benzene, not to be confused with the petroleum product, benzine; phenol, commonly known as carbolic acid; napthalene, used for making moth-balls, and anthracene, cresol and carbazol. All of them together make up about one per cent by bulk of the original coal.

PHOTOGRAPH of girl at right was taken through a cylindrical block of "Lucite," a new crystal-clear plastic, to demonstrate its transparency. Below, packing man-made camphor as it is delivered from the flaking drum. Bottom, one of the properties of "Lucite," new plastic, is its ability to convey light through itself edgewise, concentrating the illumination at the ends or edges only, as shown in this demonstration.



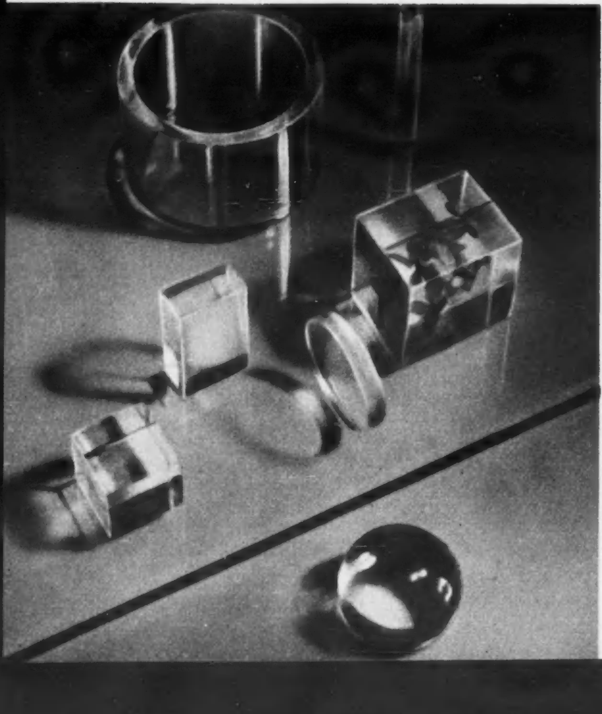
When purified, these substances are either colorless liquids or white, crystalline solids. They have a peculiar odor and so are called "aromatic compounds" but they exhibit none of the brilliant colors which appear on further treatment. When the chemist treats these liquids and crystals with nitric acid and other substances, however, they yield not only dyes but a wealth of products useful to man.

Toluene, for instance, produces not only "TNT," but a group of dyes, some intermediates for still other dyes and certain rubber chemicals. Nitrated benzene, when reduced, gives aniline and this, in turn, yields a stabilizer used in smokeless powder. And aniline might well be called the head of the family of coal-tar colors. So important is it that all such dyes are known as aniline dyes, although not all of them are actually

made from it. It does form the base, however, for indigo, one of the first synthetic dyes to gain outstanding commercial importance and still the most widely used textile color today. But don't get the idea that it is all as simple as it sounds. Indigo is one of the most difficult of all dyes to produce—and none of them is easy.

When the world war shut off the supply of foreign dyestuffs, America faced a famine of color so acute that warehouse floors were scraped to recover the spilled colors. Today American chemists make hundreds of primary colors from coal-tar derivatives and combine them to produce the several thousand hues used commercially. And if you can't find what you want

BEACH suits, above, colored with fadeless vat dyes developed through chemical research. Below, left, examples of "Lucite," the new plastic, showing how it can be molded or cast into any desired shape. Its absence of color makes it receptive to dyes and pigments of any shade wanted. Right, below, "Pyralin" coming through the "sheeter."



among them, they'll make up the exact shade you specify. Thus chemistry has produced a rainbow of beauty and fast color for everyone. Nowadays you need not be a king or queen to wear "the royal purple." There's a dye for every purpose—special dyes for cotton, silk, wool, rayon, leather, rubber, paper, even gasoline. A dye suitable for one fabric may not have an "affinity" for another, so today the number of dyes produced is almost as great as the number of products to which man wants to add color.

But that's only part of the story of coal tar. Each of the coal-tar derivatives yields many other products besides dyes. Benzene, for instance, is chlorinated to make chlorobenzene, a by-product of which is an effective moth repellent. Chlorobenzene, in turn, is treated to yield the base for several sulphur colors and a photographic developer, half a dozen dyes, intermediates to produce still other dyes, and picric acid which can be used as an explosive but which also forms the base for still more dyes. Other

SINGING through "Cellophane." The hood mutes the high notes of the coloratura soprano so they can be broadcast without fear of microphone vibrations. Left, "Pyralin" toiletware, beautiful, durable and inexpensive as compared with natural materials such as ebony and ivory which this man-made material has replaced for such purposes to a great extent.

coal-tar compounds yield as many different substances out of which are produced such materials as accelerators to speed up the vulcanization of rubber; anti-oxidants which prolong the life of automobile tires; tetraethyl lead, the active principle in anti-knock fluid for automobiles; extreme pressure lubricant bases for increasing the strength of oil films, many pharmaceutical chemicals and perfume bases.

It is difficult for anyone but a chemist to realize that the sticky, evil-smelling stuff we know as coal tar produces the aromatic bases for most of our perfumes today, but this is a case where smelling is believing. There would be no lilac or lily-of-the-valley perfumes, for instance, if it were not for coal tar because no means has ever been found for extracting the oil from these flowers. So coal tar plus chemistry offers us perfumes never produced before but also duplicates such odors as violet and rose—and it used to take twenty-five tons of violets to make one ounce of natural oil for this perfume and a ton of roses to make ten ounces of

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DEMONSTRATING magnifying power of "Lucite," above. At left, washing window with a man-made sponge. Bottom, this kitchen has "Cellophane" drapes, "Fabrikoid" table cover, synthetic finishes on furniture and refrigerator.

natural rose oil. Today every perfume on the market depends on a man-made product for its individuality and character. The whole gamut of aromatics now consists of about 1,000 materials instead of 200 or so, and the number is increasing.

The chemist's greatest triumph in this field of aromatics has been the production of man-made musk. Musk is a fixative which blends into one fragrance all the odors of a perfume and confers permanence on them. Incidentally, it is said to be the most fascinating of all odors to humans. Natural musk is obtained from a gland of a male deer in Tibet and in its impure form is valued at about $560 a pound. Natural musk cannot be produced free of all impurities, but if it could, would probably be worth $40,000 a pound. Man-made musk—not to be confused with artificial musk—has every quality of natural musk, is produced without impurities and is comparatively inexpensive. But the chemist has done more than reproduce the fragrance of the flowers. He has created new odors—fascinating scents of which nature never even dreamed.

Now let's forget coal tar and consider salt. Give one of these du Pont chemists a pinch of salt and a few other simple materials and he will create as many products as he makes out of a spruce tree or a lump of coal. Out of salt he produces things as far apart as insecticides for the farmer and cosmetics for the farmer's wife, materials to caseharden metals and others to bleach cloth as white as snow.

From salt, limestone and coal the chemist evolves neoprene—rubber that never saw a rubber tree. This substance is not synthetic or artificial rubber, but a man-made product with all the properties possessed by rubber and a number of excellent qualities which rubber does not possess. It resists oil and greases and acids and alkalies much better than natural rubber, does not check and crack on exposure to sunlight to the same extent as rubber and does not deteriorate with age as rapidly. Like rubber, neoprene must be mixed with certain pigments and vulcanized by heating and the finished product may be soft and flexible or hard and tough. It is being used widely today in the manufacture of oil and gasoline hose, printing rollers, belting, molded parts for automobiles and refrigerators, hospital sheeting, packing and piston seals for pumps and compressors, gloves and oil-proof electrical wires and cables.

Thus, from salt, we have chemistry that stretches. Salt, too, is the base of methyl chloride, a fast-freezing refrigerant; of chlorine which safeguards your water supply and of various cleaning solvents. And sodium cyanide, chemically derived from salt, makes the gears of your car wear-resistant without sacrificing strength. Other products starting from salt and known as metal cyanides are used to produce the decorative and durable finishes you find on silver-plated tableware and other metal-plated products.

Every product thus far mentioned has as its base cellulose, coal or salt. From other simple products of nature the industrial chemist evolves an array of man-made materials just as impressive and just as useful. From molasses and yeast, for instance, he gets alcohol and carbon dioxide, a refrigerant. Sulphur, charcoal and saltpeter yield black powder; sulphur plus air yields sulphur dioxide, a refrigerant; sulphur plus coke yields carbon disulphide, used in making viscose rayon, and sulphur, air and water yield sulphuric acid whose uses are legion. Nitrogen from the air and hydrogen from the water are combined under pressure with the aid of coal to produce ammonia—and then we have, not chemistry that stretches, but chemistry that blows hot or cold.

For ammonia, changing from a liquid to a gas, absorbs heat, lowers the temperature and provides refrigeration. Use the same air, water and coal with which we started to make ammonia, change the mixture of gases, vary the pressure, and you have the chief ingredient, not of a refrigerant, but of an anti-freeze to keep the radiator of your car from freezing.

Thus, man, by taking apart the simple substances provided by nature and rearranging the patterns, has progressed. Today nearly everything you use has been either created or improved by chemistry. Almost every part of your motor car, for instance, has been touched by the magic hand of the chemist and, because of chemical research, your clothing is made of better fabric and contains better dyes, your food has better protection and refrigeration, your home has better paint, furnishings and equipment. But scarcely one of these better things is what it seems. Rayon does not look like a spruce tree, the blue of your suit does not look like coal

tar, the fuel hose at your neighborhood filling station does not resemble salt or coal or limestone. Yet all were produced from just such simple materials.

And every year the development of our natural resources continues. New products, new man-made substances even more marvelous than those with which we are familiar are being born so rapidly in the chemical laboratory that man hardly learns the possibilities of one substance before another has been offered to him.

One of the latest is "Lucite," a resinous plastic material evolved by du Pont chemists which is as clear as glass but much lighter and so unbreakable that it can be bounced on a stone floor. It is produced in rods, sheets and tubes and as a molding powder which becomes plastic when heated. It can be made as a crystal clear product and in an almost unlimited variety of brilliant transparent, translucent and opaque colors. In optical qualities, clarity and general appearance, it closely approximates natural quartz crystals. A ball of natural quartz crystal costs thousands of dollars; one made of this plastic costs only a few dollars and it is difficult for even an expert to differentiate between them.

The light of the firefly can be imitated with this substance. If a rod of it is held over the rays of a mercury-vapor ultraviolet light, the material converts the invisible ultraviolet light into visible rays which glow when the rod is removed from the lamp. "Edge" lighting is also a property of this "glass." Light passes through sheets and rods, even around corners formed of the material, being visible only at the edge or fringe of the substance. Light from an electric lamp passing through a rod of "Lucite," for example, causes the end of the rod to glow like a cigar in the dark.

This quality of transmitting light edgewise through a sheet or around a curve may make this substance useful for advertising signs, for the indirect lighting of instrument panels in automobiles, airplanes and radios and for many other purposes. The material can be machined on a lathe, sawed, cut, drilled, carved, molded and worked in other ways. This glass-like resin is made of a colorless liquid, known to chemists as methyl methacrylate.

This liquid is rendered solid by polymerization, a method of treatment by which small particles of the original material grow into big ones and change their optical and structural qualities. This material is likely to be used for a thousand purposes in industry within the next few years as more and more manufacturers adapt it to their products.

To most of us, the production of a substance like "Lucite" from simple materials of nature seems a miracle. To the research chemist, it is the result of sweat, not magic. It took twelve chemists five years to produce "Lucite." When they had finished, they had evolved not an artificial glass or a substitute for glass, but a brand new product with the transparency of glass but also with many admirable qualities glass does not possess. The same is true of the other man-made products described. Rayon is not a substitute for anything. It is a man-made fabric which has found its own place in our scheme of things. The lacquer on your car is not a substitute for paint or varnish. It does a job paint and varnish could not do.

And research chemists, pioneers in creating the many new products we enjoy today, are continuing their work, studying strange new things, adding to their knowledge of raw materials and the laws which govern their combination.

"New goals are constantly envisioned by those engaged in scientific research," says Dr. C. M. A. Stine, vice-president of the du Pont Company. "There will be continued effort toward lower costs of production, improved quality, and new uses for existing products. And the chances are that new products will be created in an ever-increasing volume. The farther science penetrates into the nature of things, the wider becomes the horizon of opportunity."

So, more and more, in the future, we shall say, "things are not what they seem." And, because of that fact, this will be a better world in which to live.

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PROGRESS IN THE DEVELOPMENT OF PEST CONTROL MEANS DISCUSSED AND PROBLEMS YET TO BE SOLVED OUTLINED

EDITOR'S NOTE:- Below is an address by Dr. Tisdale at the annual meeting of the National Association of Insecticide and Disinfectant Manufacturers, Chicago, Illinois, June 7, 1937. The facts set forth show that definite advances in pest control are being made.

By Dr. W. H. Tisdale, Manager,
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Grasselli Chemicals Department,
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Research is essential to the advancement of civilization. Useful products of today are replaced by better ones tomorrow. Often entirely new and important industries result from the findings of research. No phase of our economic system, including methods of controlling destructive pests, can afford to be without research. Organized investigations directed toward the development of more effective means of pest control have not been commensurate with the importance and tremendous economic losses caused by the numerous pests that compete with man for his means of subsistence. Yet much has been accomplished. The battle front is being broadened along many lines for more extensive, concerted attacks in the future.

Changed Conditions Create New Problems

During the period of territorial expansion and occupation of new lands it was not necessary to continue to cultivate soil that had become unprofitable due to pests or other cause. Now that virgin lands are practically exhausted in our country it has become necessary for man to develop means of overcoming the numerous foes which were responsible for his migration and which he unwittingly helped spread through his means of transportation. With the growing density of our population and increasing intensity of our methods of production in industry and agriculture, conditions become more favorable for the spread, multiplication and destructiveness of pests. Plants, animals, prepared foods, clothing, buildings and numerous other items are damaged or destroyed. Man himself is tortured with bites, stings, diseases, and often death.

The losses caused by insects, fungi, and bacteria to plants, farm animals and the products of agriculture, are estimated in terms of billions of dollars annually. Add to this the damage done to man and his other means of subsistence by these pests and numerous other pests such as weeds, rodents and other destructive vertebrate animals, protozoa, various worms, destructive marine, animal and plant life and other pests, and you can form a mental picture of the tremendous importance of man's battle against pests. We know that insects

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antedate man by possibly millions of years. Many of our leading entomologists consider insects to be man's most formidable enemy. In spite of this advantage in adaptation and experience by possibly his worst enemy, man has developed and advanced to his present state of civilization within comparatively few centuries. Wars with other pests and wars among men have been added to the conflict. In the earlier stages of protection against pests mechanical methods were commonly used. In more recent years, especially during the past half century, more highly intellectual means of control have been devised. Selection and breeding of plants and animals for disease resistance and immunity, serums, vaccines, the use of natural parasites, and chemical measures, are being employed. In the earlier use of chemicals the few then known poisons were selected. The increase in insect populations, and the resulting demand for better poisons and more and heavier applications of them, has aroused the interest of government officials and the people generally over the possibility of poisoning humans who eat treated fruit and vegetables and who may, in other ways, come in contact with excessive amounts of poisonous pest control chemicals. The demand is for safer means of pest control. The challenge has been accepted by public and endowed research institutions and commercial chemical companies. Research efforts are being expanded in the direction of chemical control as well as along other important lines. The battle is between over-whelming numbers and dogged persistence on the part of the pests against the intellectual methods of man. The progress made by man so far indicates that he will probably be able to maintain if not strengthen his position in the future. This will prove true if research in insect and plant disease control proves as effective as it has in the control of human diseases.

Some Achievements of Research

Serious investigational work was directed toward the control of the diseases of humans and serious plagues were yielding to the efforts of science when the ravages of insects and diseases of farm crops and animals, and the destruction of man's other means of subsistence were still considered by many to be unavoidable acts of God. Many of the contagious and communicable diseases of man which have caused serious epidemics have been either eradicated or brought under control. Progress continues - Recently a serum is reported to have been produced that offers considerable promise for the control of pneumonia. The outstanding recent advancement in the use of chemicals for the control of human diseases has been the discovery of the use of Prontolyn (para amino-benzene sulfonamide), Prontosil (4-sulphamido-2,4 diamino-azobenzol hydrochloride) and sulfanilamide for the control of streptococcus infections. In addition to the control of other serious infections, kidney and bladder infections may be eliminated by this chemical means. A new local anesthetic ten to fifteen times as effective as ether has just been announced. This should prove an important supplement to disease control.

Effective and Safe Control Sought

When the needs become sufficiently urgent, action and results may be expected. With conditions becoming more and more favorable for the development and spread of pests, and with the greater poison hazards to humans involved in the more extensive and intensive use of chemical control measures, research organizations

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have intensified their efforts toward the development of more effective and safer means of control. Much has been accomplished within the past few decades and especially in the last few years. Much still remains to be done. There are a number of important steps which contribute to greater efficiency and safety in the control of insects and diseases with chemicals. Poisonous products are being handled with greater care to insure safety. Where it is necessary to use poisons on food materials or in household or storage they are removed by washing, aeration, and other means to protect the lives and health of humans. Better supplements such as wetting, penetrating, spreading and sticking agents and properly selected compatible inerts improve the effectiveness of pest control chemicals. The efficiency of active products may be increased through chemical combinations with other elements. In the case of the cumulative poisons the more effective compound, while still poisonous, requires less of the cumulative toxic element and may be considered safer. The most desirable thing to do is to find effective products that are non-poisonous to humans to replace the poisons and to fill the needs where satisfactory control measures are not available. Increased attention is being given to biological means of control of many parasites, such as the selection and breeding of plants and animals for disease resistance, and the use of natural enemies of the pests to effect control. Such measures do not involve poison hazards but so far they have replaced the use of chemicals only to a limited extent. The need for continued research to develop better chemical control measures is outstanding. Definite progress has been made and is being made along these various lines of attack.

Safety methods have been devised for handling solid, liquid, and gaseous poisons. Much is being done to educate the user to employ these methods in the handling and application of poisons for pest control so that valuable materials may not be lost by overzealousness in trying to eliminate all materials of a poisonous nature.

The removal of arsenic, lead, fluorine and other poisonous residues from fruit and vegetables with acid and alkaline baths is proving successful. Supplements to these baths, such as sulfonated naphthalenes, sulfated alcohols, and sulfonated phenol derivatives and their salts, which serve as wetting agents and detergents, increase their efficiency.

Assistants Made Available

The development of supplements for use with insecticides, fungicides and bactericides has been marked within the past few years. For sprays, ordinary soaps were replaced by improved casein spreaders, sulfonated oils, oil emulsions, to some extent by amine soaps, sulfite waste liquors from the paper industry and by other products. More recently the so-called hard water soaps have been found effective. Now such products as sulfonated naphthalene, sulfonated phenol derivatives, sulfated alcohols and sulfated fatty acids are being extensively used. These products, in addition to being highly effective as wetting and spreading agents, are compatible with most pest control sprays and with natural waters, weak acids, and weak alkalies. They also are effective in the preparation of wettable and dispersible powders.

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For sticking or holding the effective chemicals in place, when sprayed or dusted, the newer developments consist of the use of rosin emulsions, colloidal resinous materials and synthetic plastic products. These may be used in combination with the spreading agents or they may be used separately. Colloidal clays, soybean, wheat and other flours, and newly found gums, are proving useful in this field.

Improved inerts, such as more finely divided earths, and other powders have been developed for use, especially with powders for dusting.

New Insecticides for Chewing Insects

For the control of chewing insects, progress has been made toward the improvement of arsenate of lead and its compounding for efficient use. Attempts to develop an equally effective arsenical without the lead have not proved entirely successful, although zinc arsenate and insoluble calcium arsenates offer some promise.

The discovery of the effectiveness of the fluosilicates as stomach insecticides for possible agricultural use resulted in considerable optimism with regard to their replacing arsenate of lead and other arsenicals. However, the fluorines were found to be cumulative in the bone tissues of animals and to cause injury. Fluorine was placed under the same government restrictions as arsenic and lead. Yet due to their high degree of effectiveness against certain kinds of insects a considerable usage has developed for these fluorine compounds.

Due to its non-cumulative effects, nicotine, although highly poisonous, has been studied in various fixed or stable combinations as a stomach insecticide. Some of these products, such as nicotine tannate, nicotine bentonite (nicotine aluminum silicate) and nicotine humate or combinations with finely divided organic matter such as peat are promising for certain purposes.

The discovery that some of the extractives of the fish poison plants, in addition to the rotenone, have stomach poison value, and the adaptation of the ground or powdered roots of these plants as insecticides to make use of this discovery, has proved to be one of the outstanding developments in the control of insects attacking both plants and animals. These rotenone-bearing products have both stomach and contact insecticidal value.

Of still more recent development are a number of products, chiefly experimental, including cuprous cyanide, diphenyl amino arsenious oxide, phenothiazine, and others of less prominence. Phenothiazine has been used extensively in an experimental way and has been found under western conditions to be more effective than arsenate of lead for the control of codling moth of fruit. Results are erratic in the East. The product also has a tendency to cause dermatitis on sensitive people. Further investigations of these new compounds are under way.

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Progress in Development of Contact Insecticides

Although contact insecticides have not received the adverse criticism due to possible cumulative poisonous properties which are possessed by some of the stomach poisons, extensive investigations have been directed toward rendering the ones in use more effective and to finding new and better ones. The extensive investigations of the U.S. Department of Agriculture and other institutions of the chemical structures of rotenone, nicotine and pyrethrum and their related compounds, and their effectiveness as insecticides, have proved important in the development of better contact insecticides. The discovery by the U.S. Department of Agriculture that neonicotine is the most active of the products related to nicotine, followed by the discovery by Russian investigators of the product in its levorotary form in a plant, *Anabasis aphylla*, constitutes a definite advance. The product of this discovery known as *Anabasin* is an effective contact insecticide.

Combinations of pyrethrum and rotenone, which have the advantages of the superior paralytic action of pyrethrum and the lethal action of rotenone, are found to be useful.

The discovery of the insecticidal value of the alkyl thiocyanates is important. Although the products of the earlier discovery proved too volatile and too toxic to plants to be of practical value, later developments such as trimethylene dithiocyanate, butyl carbitol thiocyanate and lorol thiocyanate have become useful in the control of certain agricultural and household pests.

For contact insecticidal purposes, ovicides and supplements to insecticides and disinfectants generally, much improvement has been made in oils of various kinds. Highly purified hydrocarbon oils have come into more general use, the medium to heavier fractions for plant sprays and the lighter or kerosene fractions of the highest purity for use in fly sprays. Fish oils and certain vegetable oils are finding use as spreading and sticking agents for pest control products. The emulsification of oils has been studied and improved so that the proper stability and breaking properties are obtained to result in greater efficiency. Tar oils, and hydrocarbon oils containing activators or effective supplements such as cresylic acid, thiocyanates, nicotine and certain phenolic derivatives, appear promising as dormant sprays for ovicidal purposes and for the killing of the resistant stages of certain insects. Supplements other than rotenone added to pyrethrum appear to be of value in fly sprays. Fractions of pine oil and certain synthetic materials are showing promise.

Selenium and certain of its compounds have been found especially effective for red spider and other mites and certain sucking insects. However, certain selenium compounds have been found to be very poisonous to warm blooded animals unless the proper amount of sulfur is present.

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Fumigants, Disinfectants and Repellents

As fumigants, nothing has been found that equals the old and extensively used products carbon disulfide and hydrocyanic acid gas. In addition to the less poisonous compounds which have long been used such as naphthalene and its derivatives and ortho-and para-dichlorobenzenes, certain other products have been developed including ethylene oxide, ethylene dichloride and more recently the alkyl formates, tetrachlorethane, and other chlorinated aliphatic hydrocarbons. Methyl bromide is being considered. The safety of some of the last mentioned products is still in question.

Insect repellents are becoming of greater importance with the spread of the Japanese beetle. Due to the occurrence of this insect in such enormous numbers and its resistance to poisons, plants sprayed with poisons will eventually be eaten anyway. Repellents are considered the most logical means of control. Derris or rotenone bearing sprays and synthetic products, such as tetra methyl thiuram disulfide, offer considerable promise for replacing lime, arsenate of lead, and other products that produce objectionable visible residues.

As termite repellents chlorinated naphthalenes, chlorinated phenols, chromated zinc chloride, beta naphthol and alpha nitronaphthalene appear to have definite value.

For the protection of woolen fabrics and other animal products from the attacks of moths, certain highly stable organic fluorine derivatives are coming into use. Organic naphthenates of the straight chain and cyclic types have shown promise.

Extensive progress has been made in recent years in the development of more effective disinfectants. Outstanding among these developments are the uses of the water insoluble coppers, chlorinated phenols, and the organic mercury compounds. Copper carbonate has come into extensive use as a wheat seed disinfectant to control bunt or covered smut. Copper ammonium silicate, copper resinate, copper oxychloride, copper zeolite and red copper oxide are other compounds showing promise as disinfectants. The chlorinated phenols and certain of their derivatives have proved effective for the control of sap-stain of freshly sawn green lumber during the curing process and are useful in the preservation of certain kinds of wood and wood products. The organic mercurials have come into extensive use as seed, soil and lumber disinfectants. Corn seed treatment was not developed until the advent of the organic mercury disinfectants. Satisfactory dust disinfectants were not available for the treatment of the seeds of oats, barley, flax and cotton, which are now successfully treated with organic mercury dusts. The most effective of these are the aryl and alkyl derivatives of mercury. The ethyl mercury compounds are the most extensively used of these products. They are highly effective as seed and soil disinfectants for the control of sap-stain of lumber and for other purposes. Both ethyl and phenyl mercury salts are being used for certain pharmaceutical purposes.

Formaldehyde dust has been developed for the treatment of seeds and soils.

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Salicylanalide, thiuram sulfides, thiocarbamates, naphthalene derivatives, chloramine and certain organic dyes, have been found to have value for certain purposes.

In reviewing some of the advances that have been made, comparatively few new compounds have been mentioned. This, by no means, gives you a complete picture of the extensive investigational work that has been done in the fields of chemical synthesis and biological evaluation. Several thousand new compounds have been prepared and tested within the last few years. The ones mentioned have reached the stage where they are known to have merit. Others may evolve from this list later with equal or greater value.

Present Trend of Research

People have become poison conscious. The demand is for pest control chemicals that will destroy life and at the same time not injure life. In other words, the chemical must kill or control the parasite and not harm the host whether plant or animal. It must be safe to humans who apply the treatment, eat the treated products or otherwise come in contact with the control chemical. Harmless and valuable insects, fungi, and soil flora should not be destroyed by these chemicals. The fulfillment of such a requirement rests on a very sensitive balance. It depends on taking advantage of the specific differences in living matter. Both physical and chemical factors are involved. The trend is away from the more universally toxic chemicals and toward specifics. The fact that so wide a range of specificity is found among living beings, both plant and animal, which are organic in nature might of itself point to the field of organic chemicals as offering greater possibilities for developing effective, specific control measures for insects, fungi, and bacteria. The occurrence of highly effective products in plants such as nicotine, rotenone, pyrethrum and, more recently, the discovery that the extracts of certain fungi are excellent fungicides, strengthen the organic theory. The successful use of synthetic organic products such as formaldehyde, certain dyes, hexyl resorcinol, compounds of cresol and phenol (phenolic derivatives), derivatives of naphthalene, organic sulfur compounds and others are definite proof that results can be accomplished in the laboratory. Once a product is synthesized in the chemical laboratory, production and quality may be standardized and the possibilities of uniformity are much better than with the naturally occurring products. With increasing use the synthesized product is likely to become cheaper to the consumer while the opposite may be true with the naturally occurring product which is limited to the amount obtainable from the naturally fluctuating supply of toxin bearing plants available. The chances that some of our commonly grown farm crops may serve as raw material for synthetic pest control chemicals are probably as good or better than that new and valuable toxin bearing plants will be discovered somewhere in the world and grown successfully on our lands.

The prediction that through the development of specifics for the numerous uses in the pest control field our supply houses for such materials will be more like our present drug store, may not be greatly overdrawn. It seems definitely certain that in satisfactorily solving the problems now confronting us and those that no doubt will arise in the future additional and more specific products will be required.

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In the development and application of more refined pest control measures more thorough and expert service will be required. To obtain the maximum efficiency from the chemical, the insect problem or disease must be properly diagnosed and the most effective remedy applied. This of course has been and is important with the products now in use but may become increasingly important with future developments.

THE PRESENT STATUS OF SEED TREATMENT DESCRIBED WITH SPECIAL REFERENCE TO CEREAL DISINFECTION

EDITOR'S NOTE:- The excerpts given here are from a paper by Mr. Robert W. Leukel, Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture. This valuable paper was printed in Botanical Review, 2: pages 498-527, October, 1936. The numerous references are omitted, due to space limitation.

Man's unceasing struggle against the destructive forces of Nature is well illustrated by his war on plant diseases. Losses due to fungous and bacterial diseases of commercial crops in the United States amount to about a billion dollars annually (107). The annual loss caused by one disease, bunt of wheat, may amount to over 25 million dollars (38). During the 11-year period 1917-1927 smuts in oats caused an average annual loss of 50,000,000 bushels (119). These losses combined with those caused by other diseases of these and other crops, make a staggering total.

Much of this loss is preventable. The principal preventive measures include sanitation, crop rotation, and certain other cultural practices, the use of resistant varieties, and seed treatment.

The purpose of this paper is to sketch briefly the development of seed treatment, especially for cereals, and to describe the present problems, trends, and practices in that field as they apply to conditions in the United States.

No attempt will be made to review more than a small part of the prodigious amount written on the subject, or even to cite more than a small percentage of the articles perused. Some of the statements made are based on the writer's own experiments, data from which have not been published.

Historical

Seed treatment for the prevention of plant diseases, especially those of cereals, has been practiced, in one form or another, for about three centuries.

At first, in the absence of definite knowledge concerning the nature of plant diseases, preventive measures were of a more or less superstitious nature, such as sowing in the dark of the moon, or sticking branches of laurel in the grainfields "to draw the blighting vapors to them" (136). Some of the earlier materials used for treating cereal seeds were lime, salt, saltpeter, and wood ashes.

Copper sulfate probably was the first standard fungicide used, and its intelligent application dates back to 1761 (113). It did not come into general use, however, until a century later when Kuhn's (65) experiments established a basis for making definite recommendations regarding its use. Later investigators made

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other recommendations concerning the use of copper sulfate, the most important of which was that, after treatment, the grain be dipped in lime-water to prevent seed injury. Despite the advances made in seed treatment methods in recent years, many farmers still use the copper sulfate treatment for the control of bunt in wheat.

Another seed treatment method of early origin still in use is the hot-water treatment developed by Jensen (51) in 1887. It still is the only known treatment that will kill certain deep-seated fungi like that causing the loose smut of wheat (Ustilago tritici) which are not controlled by surface disinfectants. It also is used for treating certain vegetable seeds.

Formaldehyde was first advocated as a seed treatment in Germany by Geuther (32) in 1895 and in the United States by Bolley (6) in 1897. It still ranks among the foremost liquid treatments because of its cheapness and its general effectiveness, in spite of its tendency to injure the seed.

Copper sulfate and formaldehyde continued as the outstanding seed treatment materials up to about 1914. Mercuric chloride and other materials were tried but not generally recommended. In 1912 organic mercury compounds were introduced as seed disinfectants in Germany and in early experiments Riehm (104, 105) along with others found them effective in cereal-disease control. Among the first of these to be marketed was a chlorophenol mercury compound known as "Uspulun," placed on the market in Germany about 1915. Similar compounds under the trade names "Chlorophol" and "Semesan" soon appeared in the United States. These materials were used in solutions ranging in concentration usually from .25 to .75 percent. In general they were found very effective in cereal-disease control with little or no seed injury (68, 71, 106, 122, 126).

Dust disinfectants first came into prominence as a result of the work of Darnell-Smith with copper carbonate (18, 19) in Australia in 1915. Due to certain apparent advantages this form of seed treatment met with immediate popularity and started the era of dust fungicides. At first the use of dust fungicides was restricted to the control of diseases due to surface-borne organisms such as bunt of wheat; but experiments soon showed that the more deep-seated organisms, like those causing the smuts of oats (27) and covered smut and stripe of barley (73), could be reached by certain dust fungicides (69, 71, 72). From then on, liquid fungicides lost favor and dust fungicides gained in popularity, not only for treating cereal seeds but seeds of other crops. Although liquid fungicides have by no means been entirely discarded, yet if dust fungicides of equal effectiveness can be economically used, they usually are preferred.

Advantages of Dust Fungicides

Dust fungicides possess certain outstanding advantages over liquid fungicides.

1. They are more easily applied; the wet disagreeable task incidental to immersion treatments is eliminated as also is the work of drying the seed, and the danger of the seed freezing, sprouting, heating or moulding before it dries.

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2. The use of dust fungicides greatly reduces the chances of errors in seed treatment. Liquid fungicides frequently are used in excessive concentrations or the immersion period may be too long and thus impair germination. On the other hand the solution may be too dilute or the period of immersion too short to effect disease control. Certain fungicidal solutions when used repeatedly have so much of their essential ingredients taken up by the seed that additional concentrated solution must be added occasionally (28, 64). Mistakes are easily possible in adding the chemical to replenish the solution.

It also is possible to apply too much or too little of a dust fungicide, but such errors are revealed to some extent by the appearance of the treated seed. The excess dust usually is readily discernible, while if an insufficient amount is applied its failure to coat the seed properly will be evident especially if the recommended rate per bushel is 2 ounces or more. Dusts that give off fumes and thus disinfect the seed largely before it is planted, must be applied with greater precision as to amount than dusts that are relatively inert until the soil moisture acts upon them.

3. Dust fungicides furnish greater protection against recontamination of the seed.

4. They protect the seed, to some extent, against soil organisms.

5. They protect the seed against weevils and rodents (79).

6. Their application is largely independent of temperature while low temperatures decrease the effectiveness of some liquid fungicides (31, 66, 79).

Dust fungicides are not without certain disadvantages. The fine dust when inhaled may cause extreme discomfort or even illness. The vesicant action of mercurials is especially disagreeable. With the exception of formaldehyde, liquid fungicides usually do not affect the operators while being applied.

Dust fungicides may interfere with the ready flow of grain through the drill, especially those dusts applied at the rate of 2 or more ounces per bushel of seed. Conners (13), for example, found that treatment with copper carbonate increased the bulk of wheat seed 7.7 percent and reduced its rate of flow about 12 percent. Insufficient or excess soil moisture (131) or the presence of certain organic materials in the soil (115, 116) may decrease the effectiveness of some dusts that do not take effect until after sowing.

Dust fungicides, as a rule, are more expensive than liquid disinfectants.

Problems in Developing and Testing Seed Treatments

The work of testing the relative effectiveness and practicability of different fungicidal materials presents certain problems to the investigator. The first of these relates to obtaining a supply of seeds carrying sufficient infective material to provide an adequate test for the fungicide. If the organisms are entirely surface-borne, as in bunt and flag smut of wheat, and kernel smut of

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sorghum, it is a simple matter to infest the seed. But in many cases the organisms are placed by Nature deeper within the seed (27, 73), in a manner that cannot be easily and surely duplicated artificially. The disparity in results obtained by different investigators may sometimes be explained by the fact that in one case naturally inoculated seed was used and in the other the seed was artificially inoculated. This makes it desirable to secure seed from a badly infected crop, or still better, if possible, seed from the same lot from which the infected crop was grown. In some years, strange as it may seem, badly infected fields are not readily found. In other years, even though the infection may be high in the field, the weather or other conditions may not be conducive to a heavy invasion of the seed by the organisms (70). Such seed when used in seed treatment experiments yields disappointing results because it fails to test thoroughly the merits of the fungicides under study. Again, suitable seed may be available, but the conditions under which it germinates or the plants are grown may not favor development of the disease; thus another experiment may end inconclusively.

Effectiveness in disease control, however, is only one of the factors by which the relative practicability of a seed disinfectant is judged. We also must consider its "chemotherapeutic index" or margin of safety (31); its effect upon germination, stand, vigor, and yield; its corrosive effects on treating and sowing machinery (25); its injurious effects on the persons applying it or handling the treated seed; its stability, cost, and other features. For example, fungicidal dusts containing a considerable percentage of such materials as mercuric chloride or mercuric iodide are undesirable because of their corrosiveness and extremely poisonous nature. Many effective dusts have proved commercially impracticable because their high mercury content made the price prohibitive. The chief objection to certain volatile dusts is their rapid deterioration unless they are kept tightly sealed. Many effective materials, such as copper chloride, are too hygroscopic to retain the fluffiness desirable in a dust fungicide; others, like cuprous oxide, are not always chemically stable but gradually change to other forms unless specially treated.

A comparison between the large number of materials that have been reported effective in plant-disease control from time to time by various investigators and the relatively few commercially successful fungicides now available for effectively controlling these same diseases, seems to indicate that most of the substances found effective in an experimental way were found unsuitable in the manufacture of practicable fungicides, either because of undesirable physical or chemical properties or excessive cost. The production of experimental seed disinfectants was, for a time, a popular "side line" of many commercial concerns. The realization of the fact that, like Rome, good practicable seed disinfectants cannot be built in a day, has resulted in fewer of these products being put on the market in recent years.

Centralized Seed Treatment

In the earlier stages of its development, seed treatment was entirely a farm operation carried out on the farm by the farmer. The increase in the loose smuts of wheat and barley in certain sections of the country shortly after the war created a demand for seed that had been subjected to the hot-water treatment. Since this treatment is not easily carried out on the average farm, central treating stations were established in certain localities by

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energetic county agents and others, and these proved very successful (95). This lesson in centralized seed treatment was remembered after dust treatments became popular, and custom treating has become the practice in many localities. Millers or elevator operators who have installed efficient large-scale treating outfits charge from 3 to 6 cents per bushel for treating the farmers' seed grain. The disadvantage of this arrangement is the trouble involved in hauling the grain to and from the central treating unit.

This objection to custom treating is overcome by the use of portable or itinerant cleaning and treating outfits. These are compactly made and mounted on trucks. They go from farm to farm, thus saving the farmer the trouble of hauling his seed to a central plant. The charge is about 4 to 8 cents per bushel for cleaning and 2-1/2 to 5 cents for treating.

Effects of Seed Treatment

Plant stimulation from seed treatment is a subject that has received considerable investigation. It generally has been shown that any benefits derived from seed treatment can be traced to the control of organisms found either on or in the seed or in the seed bed. Occasionally, when untreated seed is sown for comparison, pronounced differences in vigor, stand, or yield are noted without any apparent indication of disease in the plants from untreated seed. These differences are then likely to be regarded as indications of stimulation. The diseases prevented or controlled may not, however, be externally evident because of lack of sporulation, i.e., so-called latent infection may be present in the plant (138, 139). This has been shown to occur especially in resistant varieties. Flor et al. (24) demonstrated it in the case of bunt, Hubbard and Stanton (48) in oat smut, and Zade (138, 139) in several cereal diseases. Others have shown that little or no benefit was derived from treatment of sound disease-free corn, planted under favorable soil moisture and temperature conditions (58, 59, 81, 82, 108, 109, 110). Similar results have been obtained with oats (74). On the other hand, when germination is delayed by cold, wet soil fungicidal dusts may protect the seeds and seedlings from attack by soil organisms which otherwise might attack and destroy the seed itself or invade the slowly developing seedling and either kill it or cause a weak plant of low yielding capacity.

With the extensive amount of research being conducted by commercial concerns and also by State and Federal agencies, on the development of disinfectants for the control of plant diseases, the composition of fungicides will continue to change. Materials now being widely used will either be further improved or will be replaced by other materials that will be more effective, cheaper, less harmful to the seed, or more acceptable in other respects. The constant aim will be to find or develop disinfectants that are highly toxic to parasitic fungi and bacteria but relatively harmless to the seeds and plants parasitized by them.

STABILITY OF FORMALDEHYDE DUST INVESTIGATED BY THE OHIO AGRICULTURAL EXPERIMENT STATION

EDITOR'S NOTE:- This report on the stability of formaldehyde dust prepared with different absorbents is reprinted from The Bimonthly Bulletin of the Ohio Agricultural Experiment Station, Vol. XXII, No. 185. The authors are Dr. J. D. Wilson and Dr. H. C. Young. Data given in the report should be of considerable value to experimenters.

Formaldehyde dust prepared by mixing commercial formalin (40 per cent formaldehyde) with an absorbent material was used by Sayre and Thomas in 1926 for the control of oat smut (1). The absorbents used in these tests were infusorial earth and finely powdered charcoal. Later experiments of a more varied nature indicated that a mixture containing approximately 6 per cent of formaldehyde was most satisfactory for general use (2, 3, 4, 5). A dust containing slightly more than this quantity of formaldehyde may be prepared by mixing 16 parts (by weight) with 84 parts of an absorbent. Shortly after the introduction of formaldehyde dust by Sayre and Thomas (1), proprietary preparations of a similar nature began to appear on the market (2, 3, 5). The absorbents used by manufacturers have included such materials as infusorial earth, kaolin, charcoal, muck, and others of high cellulose content, as well as certain combinations of some of these. For instance, a half-and-half mixture of infusorial earth and kaolin was found to possess the necessary physical characteristics for use in a fertilizer attachment of a seed drill (6, 7).

Freshly prepared dusts were, for the most part, used in the early experiments on the control of oat and onion smuts (1, 2, 3) and as soil treatments for the control of damping-off of seedlings (4, 5). Thus, it was not observed until somewhat later that good results were not always obtained through the use of the material. Investigations of reported failures to obtain control of damping-off following soil treatment showed that the dust used was from 6 to 12 months old, in most instances. Mixtures containing charcoal or muck as absorbents gave poor results most consistently. The formaldehyde content of some of these mixtures was found to have decreased from 6 to as low as 2 per cent 12 months after manufacture. In view of these facts, it was decided to compare the behavior of a series of dust mixtures, prepared with a wide variety of absorbents, over a period of from 6 to 12 months after their preparation.

In February, 1935, a series of dusts (containing 6 per cent of formaldehyde) was prepared, in which formalin was mixed with several quite different absorbents (8). In addition, trioxymethylene (paraformaldehyde) and a proprietary source of formaldehyde (Compound A) were mixed with kaolin. Quantities of these various mixtures were placed in 2-quart fruit jars immediately after preparation. The jars were sealed in the usual manner with rubbers and metal

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covers and then placed in a cool, dark storage for later use. Three proprietary mixtures which were included in this series were removed from the original containers and treated in the manner just described for the special preparations. One jar of each mixture was used the next day for an immediate test of formaldehyde content. This was determined by the A.O.A.C. official method. At the end of 3 and 7 months, additional determinations were made. The relative efficiency of the various mixtures in controlling the damping-off of seedlings was also tested at these intervals. Some of the results obtained are shown in Table 1.

TABLE 1.-Preliminary Trial of Possible Formalin Absorbents and Sources of Formaldehyde

Material	Formaldehyde source	Formaldehyde content: Day following preparation	At end of 7 months	Loss	Seedling emergence from soils treated at end of experiment
		Pct.	Pct.	Pct.	Pct.
Kaolin...........	Trioxymethylene*	6.11	5.95	2.5	80
Sawdust..........	Formalin	6.47	6.08	5.5	85
Kaolin...........	Compound A**	6.20	5.81	6.3	45
P.A.C.***........	Formalin	6.99	6.48	7.3	90
Kaolin + infusorial earth......	Formalin	6.18	5.67	7.3	90
Form-o-fume****..	Formalin	6.28	5.75	8.4	84
Marl.............	Formalin	5.98	4.75	20.6	82
Muck.............	Formalin	5.48	4.11	25.0	74
Formo-dust*****..	Formalin	6.00	3.92	33.7	72
Muck + water******....	Formalin	4.97	3.83	36.0	73
Gypsum...........		2.98	2.51	58.0	60
Charcoal.........		4.80	1.01	83.0	45
Check............					42

*Trioxymethylene by Merck, added to kaolin.
**Compound A-a formaldehyde source by Pittsburgh Plate Glass Co.
***Prepared by Grasselli Chemical Co., with infusorial earth as an absorbent.
****Prepared by Rohm and Haas Co., with grain hulls as an absorbent.
*****Prepared by Kiger Chemical Co., with muck and kaolin as absorbents.
******Water (20%) added to muck in addition to the formalin.

The formaldehyde content of some of the mixtures had decreased quite markedly only 1 day after preparation. This decrease was most rapid for gypsum, charcoal, muck, and marl (a product containing calcium carbonate, clay, and some organic matter) in decreasing order. Formo-dust, in which formalin is absorbed in a mixture of dry muck and kaolin, lost about one-third of its original formaldehyde content in 7 months; the original formaldehyde content of the mixture made up of 16 parts of formalin, 16 of water, and 68 of dry muck decreased in a similar amount. The loss of formaldehyde 7 months after preparation was

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greatest when finely ground charcoal was used as the absorbent. It seems likely that this material may act as a catalyst in breaking down the formaldehyde absorbed by it. The mixture containing Compound A lost comparatively little of its formaldehyde but failed to give satisfactory control of damping-off in this experiment, as shown in the last column of Table 1. Most of the mixtures showing a loss of formaldehyde in excess of 20 per cent in a 7-month period suffered a corresponding loss in fungicidal efficiency. Thus, all of these and the mixtures containing marl and Compound A were regarded as unsatisfactory and, with the exception of Formo-dust, were not included in a second experiment, which was started in September, 1935.

The mixtures used in this second test were prepared in much the same manner as that described for the first, but they were stored in friction top tinned cans of 1-quart capacity. These were further sealed by dipping the tops in sealing wax. The proprietary mixtures used in the first experiment were also included in the second, as was the trioxymethylene-kaolin mixture. Another, known as Formacide, was added. Tests of formaldehyde content and fungicidal efficiency were again made on the day following preparation and after 3, 6, and 13 months. Some of these data are given in Table 2. The fungicidal efficiency of each mixture, as indicated by the percentage of seedling emergence from individual lots of treated soil, is shown for the end of the experiment only, in the last column of the table. Variations in this property were very small, except for trioxymethylene, which failed to give satisfactory control of post-emergence damping-off. Both Formacide and Formo-dust showed a greater loss in formaldehyde than did the trioxymethylene mixture, but still gave better control of damping-off. The results obtained with the first five mixtures listed in Table 2 were regarded as highly satisfactory. Either kaolin, infusorial earth, or a mixture of the two, and such materials as finely ground sawdust or grain hulls may be considered as good absorbents for use in the preparation of formaldehyde dust which is to be stored for some time before use as a seed or soil treatment for disease control. Charcoal, muck, marl, and gypsum should not be considered unless the dust is to be used immediately after preparation.

TABLE 2.-Relative Stability of Formaldehyde on a Group of Selected Absorbents

Absorbent	Formaldehyde content			Seedling emergence from soils treated at end of experiment
	Day following preparation	After 13 months	Loss	
	Pct.	Pct.	Pct.	Pct.
Kaolin	6.21	6.11	1.6	82.0
Kaolin and infusorial earth	6.28	6.12	2.6	79.5
Sawdust	6.27	6.05	3.5	80.3
Infusorial earth (P.A.C.)	6.94	6.65	4.2	82.0
Grain hulls (Form-o-fume)	6.69	6.27	6.3	79.8
Kaolin + trioxymethylene	6.10	5.67	7.1	71.4
Formacide*	6.87	6.23	9.3	79.3
Muck + kaolin (Formo-dust)	6.06	5.24	13.6	79.5
Check				35.1

*A preparation by Hammond Paint and Chemical Company.

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SUMMARY

Most of the early experimental work with formaldehyde dust was done with freshly prepared mixtures of formalin and an absorbent; as a result, it was not apparent until somewhat later that its effectiveness as a fungicide might decrease quite markedly with age, even though it was stored in airtight containers. Chemical analysis showed that the original formaldehyde content of mixtures which failed to give the expected control of damping-off had decreased from 50 to 75 per cent in some instances. This decrease was usually greatest with dusts in which charcoal had been used as an absorbent.

With these facts in mind, formalin was added to a wide variety of absorbents and the resulting mixtures were stored in glass jars in a cool, dark room. These dusts were analyzed for formaldehyde by the official A.O.A.C. method immediately after preparation and at the end of 3 and 7 months. Decreases in excess of 20 per cent in the original formaldehyde content occurred with marl, muck, gypsum, and charcoal. Corresponding decreases with kaolin, infusorial earth, sawdust, and grain hulls varied between 2.5 and 8.4 per cent.

In a second experiment selected formalin-absorbent mixtures were stored in friction top tinned cans, further sealed with wax, over a period of 13 months. Decreases in the original formaldehyde content of dusts prepared with kaolin, infusorial earth, sawdust, and grain hulls varied only between 1.6 and 6.3 per cent during the period of the experiment; these materials may therefore be regarded as satisfactory absorbents for the preparation of formaldehyde dusts which are to be stored or held for a considerable period before use. On the other hand, charcoal, muck, marl, and gypsum are not to be recommended unless the dust is to be used at once.

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INTENSIVE STUDIES OF COTTONTAIL RABBITS CONDUCTED UNDER AMERICAN WILDLIFE INSTITUTE COOPERATIVE PLAN

EDITOR'S NOTE:- Long delayed, though not too late, there is being developed proper realization of the importance of wildlife in our national economy. Among the agencies which are contributing notably to a better appreciation of the economic value of wildlife is the American Wildlife Institute. This organization is fortunate in having the cooperation of the United States Biological Survey, state game commissions and nine land grant colleges in research and demonstration projects it is sponsoring.

By C. M. Palmer, Assistant Secretary,
American Wildlife Institute,
Investment Building, Washington, D. C.

Molly Cottontail is an important personage in wildlife circles. And this means that she is important to man. Therefore, it is only proper that she should demand a major position as a subject of study at two of the Cooperative Research and Demonstration projects of the American Wildlife Institute. At Ohio State University and Connecticut State College, the daily activities, habits and needs of "Molly" and her lord and master, "Br'er," are coming under the careful scientific scrutiny of specially trained experts and students of wildlife management. These men are ferretting out ways and means of making the lives of Br'er Rabbits happier and are hoping to make two (or more) bunnies grow where but one or none grew before.

Ranging over practically the entire country from Central America north into Canada and from one sea coast to the other, the cottontail rabbit is, if not the most important animal, certainly one of the most important of all our mammals. This importance is based not only on the fact that she heads the list of game species. This is sufficient to make any animal of primary importance. But there are other more fundamental biological aspects of this animal's life that place it almost in a class by itself.

The rabbit is basically a prey species, and seems to have been almost designed primarily to feed predatory species, including man. Ernest Thompson Seton places the food value to man of the annual wild rabbit crop at $25,000,000.

"Br'er Rabbit" has no defense other than a speedy flight and an unusual ability to hide effectively, but "Molly" is prolific to a high degree. She must bear the burden of constant predation from all sides by replacing at a high rate the rabbits taken for food. She starts to bear young at the early age of one year and will yield three or four litters of from four to seven young each year.

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Survival Rate of Young

Under the supervision of Dr. Lawrence E. Hicks, scientist in charge, E. D. Martin investigated many phases of the cottontail's life at the Ohio State project. The work in Connecticut was carried on by Dr. Paul Dalke, who has made the cottontail a special object of study for many years. The information contained herein is but a brief, partial report of their observations. The work has not proceeded to the point where completely definite conclusions can be reached as yet.

The results of these studies will be of interest not only to sportsmen and naturalists but to the general public as well. Animals are always interesting and there are few who do not have a more or less intimate acquaintance with rabbits of one breed or another.

Among the earliest of the "replacements" of the year are young "bunnies" scampering across the fields or the very lawns of country or even suburban homes. They grow rapidly. They provide pleasure the year 'round.

A careful search for rabbit nests was made at the Ohio project during last year's work and forty-two were located. These were kept under close observation. Most of them were found in oat or rye stubble and were surrounded by a "cover" of ragweeds, foxtail grasses, sweet clover and bluegrass. What happened to most of these is shrouded in the mystery of the wild, a toll of Nature which naturalists are attempting to solve. It is only known that twenty-eight were destroyed before the home became a nursery. Thirty-eight young were born in the other fourteen nests. There were an average of 2.92 young per brood for the period of April, May and June during which the nesting studies were made. This is a slightly lower average than has been reported by other observers.

While many of these young were found well advanced and playing in the vicinity of the nest most of them were located before their eyes were open. One nest contained three such youngsters which had succumbed to enemies even before they had had a warning of danger. Their eyes were not open, but their throats were. They had been slit by a murderer which left no incriminating evidence. Who the murderer was no one knows now -- and this fact is one reason why predation research is necessary. The lives of these little creatures hang by flimsy threads.

Habits and Haunts of Adults

It is difficult to follow the young rabbits in the wild closely enough to determine survival rate but as they developed into adults their habits and favorite haunts were more easily determined in the studies in Ohio and in Connecticut. The old rabbits of Connecticut showed a decided preference during April for an environment predominant in either birch and pitch pine or oak and hickory. Sixty percent of their time was spent in the shelter of these surroundings. Swamps, of both herbaceous and tree types, were next in popularity with these long-eared residents who spent 20 percent of their time in this cover. Surprising as it may seem, the cultivated regions were least popular at this period and only two percent of the rabbits' time was spent in such places.

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Daily activity starts about 6:30 in the evening and is continued through the night until about 6:30 in the morning. Rather definite routes of travel are followed in these nocturnal sojourns. It was observed that the females confined their wanderings more closely to the protective cover of hedgerows, while the more adventurous males roamed abroad over as many as ten acres.

Daylight finds the cottontail in the shelter of the "form," which is a protected nook in which to relax and enjoy a degree of safety from natural enemies and the elements during the hours of day. There has been much interest at the Connecticut project in these daytime haunts of the rabbit. Readings taken by means of electrical recording devices show that adult rabbits prefer an atmosphere of approximately 50 percent or less full sunlight for these hours.

Studies of Food Habits

During the period of these studies there has also been conducted a study of perhaps the most important feature of the cottontail's existence. The food of any wild creature is of basic importance not only to the animal itself but to man as well. To the animal, life depends on the food it eats; to man, what each species eats determines its economic importance. The efficient management of wildlife is impossible without a detailed and thorough understanding of the food habits of every species for which management is attempted. Food habits vary considerably with seasonal availability of the numerous types of food utilized by the individual species.

As an example, the Connecticut researches indicated that during April the cottontail's food habits changed from shrubs to herbaceous growth. These Yankee rabbits showed a preference in their feeding for cranberry, timothy, sheep laurel, clover, maple leaf viburnum, club moss, wintergreen, common rush, red maple, chickweed, gray birch and others.

A study of plants and grains utilized by rabbits on free range in Ohio was conducted weekly and a definite seasonal variation was quite obvious in the food of these Buckeye rabbits as well. Alfalfa, medium red, alsike and sweet clover were utilized in that order. Only the tender shoots of red top or blue grass were of value apparently and wheat shoots were eaten from the time they appeared above ground. Corn and soybeans, including the foliage, were of first importance during the fall and constituted the basic part of the food consumed.

It has been pointed out that these studies are entering their second year of a five year research period and conclusive results cannot be expected as yet, nor can positive recommendations for the management of any species yet be given. Management methods designed to increase the rabbit population, are being developed and tried. It will be of interest, however, to sportsmen and others interested in helping develop a wild rabbit crop to know what was used at Ohio State University to encourage a local crop of these animals for specific study.

Food, which no wild creature seems able to resist, was the inevitable bait used in these experiments. These plantings of rabbit food were carefully planned and skillfully executed. The plants used were based on available knowledge of the cottontail's food preferences, and located where they would be most accessible to them.

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The margins of the clearings on the management area adjacent to woods cover were planted to a mixture made up of equal parts of alfalfa, lespedeza, timothy, red top, medium red, alsike and sweet clover. Adjacent to these marginal plantings strips of wheat were sowed. Then, in addition, there was laid out a series of rows of succulent vegetables, each consisting of one of the following: lettuce, parsley, cabbage, carrots, turnips, rutabagas, artichokes, and sugar beets. Thus a wide variety of food was made available to the local rabbits inducing them to stay, breed and multiply in this land of plenty where they might benefit two races, their own and that of homo sapiens.

This is but a brief partial report in words of one syllable of one of a long series of highly technical research and demonstration projects being conducted not only for the benefit of the sportsman and better hunting, but for the benefit of the people as a whole, in an effort to stabilize and restore the biological basis of the life of the nation. This work is to continue for a period of five years. But it must be expanded and continued indefinitely until the information sorely needed to manage and maintain valuable wildlife resources is acquired and made available to the general public. The American Wildlife Institute is designed to provide funds for this work. It needs the cooperation and generosity of many people to finance these undertakings, and such cooperation will be welcomed.

A NEW AND EFFECTIVE CORE PUNCH BAR FOR BLASTERS OFFERS MANY ADVANTAGES OVER TOOLS FORMERLY USED

EDITOR'S NOTE:- Agricultural engineers and practical blasters consider the development of the tool described and illustrated here as a distinct and valuable contribution to ditch and certain other blasting operations.

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Blasting ditches with dynamite is an accepted method of excavation in wet soil. The technique of blasting has steadily been improved. However, it was not until recently that there was made available a thoroughly satisfactory tool for ditching work. Such a tool is the core punch bar designed by H. O. Ashley, of Sibley, Illinois. This is looked upon as a decided advance in ditch blasting equipment.

The Ashley Core Punch Bar is a combination of hole-making and dynamite-loading tool. There has always been some type of core punch bar for making holes in a type of soil where the hole will not remain open of its own accord until dynamite was loaded therein. These tools, mostly, have been makeshifts in that, particularly in sandy soil, it was seldom possible to place dynamite at the desired depth.

New in Design and Operation

This core punch bar overcomes all former difficulties by applying the principle of a pile driver to the old method of using the core punch bar. This is done by using 1-1/2" standard pipe, with handles attached, as an outside shell. The core which fits inside the shell is made from 1" standard pipe, having a steel point on the lower end 1-5/8" in diameter and a pipe "T" handle on the upper end. The point fits closely inside of the shell, but the core pipe fits loosely in the shell, so that any material sliding by the point will not foul the core. There are two steel rings; one welded to the top of the core, and one welded on the top of the shell. These are the key to the lasting quality of the tool, inasmuch as they give and take the shock in the operation of the bar. The core is placed inside the shell and the two together are pushed as far as possible into the ground at a point where a load is desired. The handle of the core is then swung at right angles to the handle on the shell; the core then becomes a pile driver to drive the shell to any desired depth. The point on the core extends below the shell so that at each stroke the point goes through the end of the shell, wedging out any material which might enter the shell and forcing material below the shell to one side. At the same time, a steel ring at the top of the core hits the shell at each stroke, driving it deeper into the soil.

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All this sounds complicated, but is actually a very simple operation. When the shell has been driven to the desired depth, the core is removed, and the dynamite is dropped into place, and can be held there with a wooden tamping stick while the shell is pulled free.

Advantages When Working Under Water

When working in several inches of water, one of the difficulties to overcome is obtaining the correct spacing of holes. It will be remembered that the criterion of any good ditch blasting job is uniformity of loading, uniformity of spacing, and uniformity of depth of hole. This always is difficult to achieve where water covers the ground, making location of holes already loaded difficult to find. To overcome this, two shells are used with each core; the shells can be marked with paint or a file, so that they can be driven to absolutely the correct depth. After one shell is loaded, but before it is removed, the second shell is driven into place so that the correct distance between the two loads can be obtained with the minimum of difficulty. In other words, this is a two man operation, one shell being driven into place while the second shell, already driven, is being loaded.

On one rather extensive ditch blasting job where a crew had been working efficiently with other tools for more than two weeks, this tool was brought on the job to be tried out. After three days of working with the Ashley Core Punch Bar, the foreman of the crew stated that the work had been speeded up 50% due to the use of this piece of equipment. We consider the development of this tool the greatest advance that has been made in the technique of ditch blasting in the past two years. The best feature of all in connection with this tool is that it is a simple piece of equipment which can be made by any pipefitter or blacksmith.

It is expected that thousands of these tools will be made locally for ditch blasting operations within the next year.

As a Stump Blasting Tool

In stump blasting operations where the ground is low, wet and of a sandy nature, and particularly where the stumps are green, it is usually a difficult job to get the hole made in the proper place for the loading of the dynamite charge - this due to the fact that often sandy soil will fill in the hole as fast as it is made, or that a bar or auger will push a small green root to one side, which root will spring into the hole after the tool is removed, so that a dynamite cartridge cannot be pushed into correct position. It has been found that the Ashley Core Punch Bar can be used very effectively under these rather difficult conditions. The pile driving operation enables the blaster to drive the shell of the tool into the correct position, loading thru the shell enables the blaster to get the dynamite in the proper position without having to fight small green roots.

It is expected that in the near future other uses will be found for this most versatile of blasting accessories.

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ASHLEY CORE PUNCH BAR